

5 **SYSTEM AND METHOD FOR AUTOMATICALLY PROTECTING
PRIVATE VIDEO CONTENT USING EMBEDDED CRYPTOGRAPHIC
SECURITY**

Field of the Invention

10 The present invention relates in general to private video content security
and, in particular, to a system and method for automatically protecting private
video content using embedded cryptographic security.

Background of the Invention

15 Digital video cameras have become increasingly popular and are
commonly used by professionals and consumers alike to produce videotaped
movies or, simply "videos." Digital video cameras differ from conventional
movie cameras by storing information on cartridges of electronic tape, rather than
on photographic film reels. Images are converted and stored as a continuous
electronic signal streamed onto videotapes for storage, editing and viewing.

20 The number and types of users of video camera technology has continued
to grow for several reasons. Recording videos in digital form originally required
significant amounts of storage capacity. However, recent advances in providing
increased storage capacity at lower cost have made digital video camera
technology available to a wider user base. Further, videos are more flexible than
film and can be exchanged electronically, including over digital data transmission
25 means, such as the Internet. Finally, *de facto* standardized video formats allow
device-independent playback, even using commonly available Web-browsers.

30 The availability of standardized data formats and the ease of dissemination
can facilitate the creation and distribution of illicit copies. Conventional digital
video cameras, including recorders and players, lack fundamental security
measures to protect against the unauthorized use and compromise of private video

content and to provide trustworthy authentication of authorship. Several recent examples of video compromise and theft underscore the need for effective security for private video content. In one notorious case, a private video taken of a celebrity couple was stolen and posted on the Internet, resulting in
5 embarrassment and harm to their reputations. In other instances, stolen video content has been reproduced and sold without authorization, thereby resulting in lost profits.

Similarly, digital video content can be easily fabricated or altered. Conventional digital video cameras, including recorders and players, likewise
10 lack means for authenticating the identity of the author. Authentication is particularly important in such fields as law enforcement where the veracity of data and identity of authorship play critical roles.

In the prior art, copy guard protections have long been used to protect commercially produced videos. However, only rudimentary security measures
15 using basic password protection exist for protecting private video content. Typically, a password is applied to the recorded digital data file and playback is disabled, absent the correct entry of the password. This form of password protection, though, protects the media as a whole and not the individual parts or frames. Moreover, the password is generally applied after recording is complete
20 and not as part of the recording or playback processes. Thus, the video content is at risk of compromise until the password is secured. For these reasons, password security offers only marginal protection and is easily compromised.

Therefore, there is a need for an approach to providing embedded security and authentication to private digital video production to protect content during
25 playback and to authenticate an author. Preferably, such an approach would incorporate flexible security intrinsic to both the recordation and playback processes using a cryptographic security scheme.

There is a further need for an approach to providing embedded security and authentication on digital video production devices. Preferably, such an
30 approach would selectively provide on-the-fly symmetric or asymmetric

encryption (or both) of recorded data and would further provide trustworthy authentication as an integral part of the data recordation process.

Summary of the Invention

5 The present invention provides a system and method for cryptographically protecting private video content during the recordation and playback processes. Individual frames are extracted during the image recordation process. Each frame is encrypted using an encryption cryptographic key prior to storage on a preferably transportable storage medium, such as a videotape. Upon playback, a decryption cryptographic key is preferably first credentialed, then used to decrypt
10 the encrypted frames retrieved from the videotape. The decrypted frames are reassembled into a reconstructed video signal for playback. The encryption and decryption cryptographic keys are preferably asymmetric public and private keys, respectively, but could also be symmetric cryptographic keys.

15 The invention also provides private video content automatically authenticated using embedded cryptographic security, either alone or in conjunction with the encryption of video content. For security reasons, only frames that are "signed" can be verified for authorship. Multiple frames could be signed with a single signature to enhance performance, but each frame is preferably signed individually.

20 An embodiment of the present invention is a system and a method for automatically protecting private video content using embedded cryptographic security. A substantially continuous video signal representing raw video content is divided into individual frames. Each frame stores a fixed amount of data in digital form. Each individual frame is encrypted into encrypted video content
25 using an encryption cryptographic key. The encrypted frames is stored on a transportable storage medium. Encrypted frames are retrieved from the transportable storage medium. A decryption cryptographic key is verified prior to decryption. Each encrypted frame is decrypted using the decryption cryptographic key. The decrypted frames are combined into a substantially
30 continuous video signal representing the raw video content in reconstructed form.

5 A further embodiment is a system and method for encrypting private video content using embedded cryptographic security. A substantially continuous video signal representing raw video content is received. The data signal is divided into individual frames which each store a fixed amount of data in digital form. Each individual frame is encrypted into encrypted video content using an encryption key selected from a cryptographic key pair. The encrypted frames is stored on a transportable storage medium for retrieval and decryption using a decryption key selected from the cryptographic key pair.

10 A further embodiment is a system and method for decrypting private video content using embedded cryptographic security. Encrypted frames are retrieved from a transportable storage medium. The encrypted frames store raw video content encrypted using an encryption cryptographic key selected from a cryptographic key pair. Each encrypted frame is decrypted using a decryption cryptographic key selected from the cryptographic key pair. The decrypted frames are combined into a substantially continuous video signal representing the raw video content in reconstructed form.

20 A further embodiment is a system and method for automatically authenticating private video content using embedded cryptographic security. A substantially continuous video signal representing raw video content is divided into individual frames. Each individual frame stores a fixed amount of data in digital form. A fixed-length original cryptographic hash is generated from at least one such individual frame. The original cryptographic hash is encrypted using an encryption cryptographic key. The encrypted original cryptographic hash is stored as a digital signature on a transportable storage medium. The digital signature is retrieved from the transportable storage medium. The encrypted original cryptographic hash is decrypted using a decryption cryptographic key. A verification fixed-length cryptographic hash is generated from at least one such individual frame. The verification cryptographic hash and the original cryptographic hash are compared.

30 A further embodiment is a system and method for digitally signing private video content using embedded cryptographic security. A substantially continuous

video signal representing raw video content is received. The data signal is divided into individual frames. Each individual frame stores a fixed amount of data in digital form. A fixed-length original cryptographic hash is generated from at least one such individual frame. The original cryptographic hash is encrypted
5 using an encryption cryptographic key selected from a cryptographic key pair. The encrypted original cryptographic hash is stored as a digital signature on a transportable storage medium for retrieval and verification using a decryption key selected from the cryptographic key pair.

A further embodiment is a system and method for verifying digitally
10 signed private video content using embedded cryptographic security. A digital signature is retrieved from a transportable storage medium. The digital signature contains an original cryptographic hash encrypted using an encryption cryptographic key selected from a cryptographic key pair. The encrypted original cryptographic hash is decrypted using a decryption cryptographic key selected
15 from the cryptographic key pair. A verification fixed-length cryptographic hash is generated from at least one individual frame retrieved from the transportable storage medium. The verification cryptographic hash and the original cryptographic hash are compared.

Still other embodiments of the present invention will become readily
20 apparent to those skilled in the art from the following detailed description, wherein is described embodiments of the invention by way of illustrating the best mode contemplated for carrying out the invention. As will be realized, the invention is capable of other and different embodiments and its several details are capable of modifications in various obvious respects, all without departing from
25 the spirit and the scope of the present invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not as restrictive.

Brief Description of the Drawings

FIGURE 1 is a block diagram showing a system for automatically
30 protecting and authenticating video content using embedded cryptographic security, in accordance with the present invention.

FIGURE 2 is a process flow diagram showing the encryption of the video content using the video camera of FIGURE 1.

FIGURE 3 is a process flow diagram showing the decryption of encrypted video content using the video player of FIGURE 1.

5 FIGURE 4 is a block diagram showing the components of the video camera of FIGURE 1.

FIGURE 5 is a block diagram showing the components of the video player of FIGURE 1.

10 FIGURE 6 is a flow diagram showing a method for automatically protecting video content using embedded cryptographic security, in accordance with the present invention.

FIGURE 7 is a flow diagram showing a routine for encrypting video content for use in the method of FIGURE 6.

15 FIGURE 8 is a flow diagram showing a routine for decrypting encrypted video content for use in the method of FIGURE 6.

FIGURE 9 is a process flow diagram showing the digital signing of the video content using the video camera of FIGURE 1.

FIGURE 10 is a process flow diagram showing the verification of digitally signed video content using the video player of FIGURE 1.

20 FIGURE 11 is a flow diagram showing a method for automatically authenticating video content using embedded cryptographic security, in accordance with the present invention.

FIGURE 12 is a flow diagram showing a routine for digitally signing video content for use in the method of FIGURE 11.

25 FIGURE 13 is a flow diagram showing a routine for verifying digitally signed video content for use in the method of FIGURE 11.

FIGURE 14 is a process flow diagram showing the digital signing of encrypted video content using the video camera of FIGURE 1, in accordance with a further embodiment.

FIGURE 15 is a process flow diagram showing the authentication of digital signed encrypted video content using the video player of FIGURE 1, in accordance with a further embodiment.

Detailed Description

5 FIGURE 1 is a block diagram showing a system for automatically protecting and authenticating video content using embedded cryptographic security 10, in accordance with the present invention. Video content 11 is produced using a video camera 12 to record (transition 7) moving images and sound. Generally, the video content 11 is private video content originally
10 recorded as original content and not as mass produced video content intended for commercial distribution. The video camera 12 translates the light and sound from a moving image into a substantially continuous, preferably digitized, signal that is recorded electronically on a transportable storage medium, such as a videotape. The videotape can be viewed using a video player 15 which generates a
15 reconstructed and substantially continuous signal for display on a television, monitor or similar viewing screen 17.

 The video camera 12, videotape, and video player 15 are conventional devices as known in the art, but the video camera 12 and video player 15 are augmented with embedded cryptographic security features as described herein.
20 As well, the video camera 12 could be any form of video recording device, including a video cassette recorder (VCR), and the video player 15 could be any form of video playback device, including a video camera or personal computer system. Alternatively, the videotape itself could be crypto-enabled to provide legacy cryptographic security, such as described in the related commonly-
25 assigned U.S. Patent Application No. _____, entitled "System And Method For Automatically Protecting Private Video Content Using Legacy Cryptographic Security," filed _____, pending, the disclosure of which is incorporated by reference.

 The video content 11 recorded by the video camera 12 is automatically
30 protected using embedded cryptographic security. An encryption cryptographic key ("encryption key") 13 is used during the recordation process by the video

camera 12 to automatically encrypt the video content 11 prior to storage
(transition 8) onto the videotape as encrypted video content 14, as further
described below in FIGURE 3. Similarly, a decryption cryptographic key
("decryption key") 16 is used during the playback process by the video player 15
5 to automatically decrypt the encrypted video content 14 following retrieval from
the videotape (transition 9), as further described below with reference to FIGURE
4.

In the described embodiment, an asymmetric, or public key, encryption
scheme is preferred, using a public key and private key as the encryption key 13
10 and decryption key 16, respectively. Three commonly known public key
encryption schemes are the RSA, TwoFish and Diffie-Hellman encryption.

Alternatively, a symmetric cryptographic scheme could also be used,
using the same cryptographic key for encryption and decryption. Asymmetric and
symmetric cryptographic schemes are described in R. Orfali, "Client/Server
15 Survival Guide, 3rd Edition," Ch. 7, John Wiley & Sons, Inc. (1999), the
disclosure of which is incorporated by reference. An exemplary public key
cryptographic system suitable for use in the present invention is the PGP Desktop
Security product, licensed by Networks Associates Technology, Inc., Santa Clara,
California.

20 The video player 15 preferably further includes means for credentialing a
user attempting to decrypt encrypted video content 14 retrieved from the
videotape using a decryption key 16. For example, public key cryptographic
schemes generally require the entry of a pass-phrase or password to validate the
identity of a user attempting to decrypt content encrypted using a corresponding
25 private key. The credentialing means could be by way of a keyboard or similar
input device.

In a further embodiment, the video content 11 recorded by the video
camera 12 is automatically authenticated using the embedded cryptographic
security. The encryption key 13 is used during the recordation process by the
30 video camera 12 to automatically digitally sign the video content 11 prior to
storage (transition 8) onto the videotape, as further described below in FIGURE 9.

Similarly, the decryption key 16 is used during the playback process by the video player 15 to automatically verify the digitally signed video content 11 following retrieval from the videotape (transition 9), as further described below with reference to FIGURE 10. To perform automatic authentication, a private key is used as the encryption key 13 and a public key is used as the decryption key 16. Automatic authentication could be performed in combination with automatic protection to ensure that the video content 11 is protected and the proper identity of the author is ensured, as further described below with reference to FIGURES 14 and 15.

FIGURE 2 is a process flow diagram 20 showing the encryption of video content 11 using the video camera 12 of FIGURE 1. The video content 11 is represented by a substantially continuous signal 21 that is generated by the video camera 12 as an electronic representation of the images and sounds being recorded. The continuous signal 21 is divided (transition 22) into discrete frames 23 of information having a fixed size. Each frame is encrypted (transition 24) using an encryption key 25, as further described below with reference to FIGURE 7, to generate encrypted frames 26. The encrypted frames 26 are then recorded (transition 27) onto a videotape 29. Note only encrypted video content 14 passes the physical boundary 28 separating the video camera 12 from the videotape 29.

FIGURE 3 is a process flow diagram 30 showing the decryption of encrypted video content 14 using the video player 15 of FIGURE 1. A videotape 31 storing the encrypted video content 14 is read (transition 32) by the video player 15. Note only encrypted video content passes the physical boundary 33 separating the videotape 31 from the video player 15. The encrypted video content 14 is retrieved as a sequence of encrypted frames 34 generated by the video camera 12 during the encryption process 20. Each encrypted frame 34 is decrypted (transition 35) using a decryption key 36, as further described below with reference to FIGURE 8. The decryption key is first credentialed using a pass-phrase or password (not shown) prior to decrypting the encrypted frames 34. The decrypted frames 37 are reassembled (transition 38) into a reconstructed continuous signal 39 for viewing, processing or storage.

The video camera 12 and video player 15 include cryptographic operating logic as further described below with reference to FIGURES 4 and 5, respectively, for encrypting and decrypting video content. In the described embodiment, the operating logic is implemented as part of an embedded system.

5 However, the processing logic could also be implemented in programmed digital computing devices consisting of a central processing unit (CPU), random access memory (RAM), non-volatile secondary storage, such as a hard drive or CD ROM drive, network interfaces, and peripheral devices, including user interfacing means, such as a keyboard and display. Program code, including software
10 programs, and data are loaded into the RAM for execution and processing by the CPU and results are generated for display, output, transmittal, or storage.

In addition, each process flow 20 and 30 can be implemented as a computer program, procedure or module written as source code in a conventional programming language, such as the Java or Visual Basic programming languages,
15 and can be presented for execution to a processor as object or byte code, as is known in the art. The various implementations of the source code and object and byte codes can be held on a computer-readable storage medium or embodied on a transmission medium in a carrier wave.

FIGURE 4 is a block diagram showing the components 40 of the video
20 camera 12 of FIGURE 1. For clarity of presentation, only the components pertinent with reference to the encryption process 20 (shown in FIGURE 2) are described, as the remaining opto- and electro-mechanical functions would be readily known to one skilled in the art. In addition, sound recordation and reproduction components have been omitted, as the processing of sound data is
25 analogous to image data and would be handled in an identical manner.

A raw image is received through a lens 42 and converted into a substantially continuous signal by a charge-coupled device (CCD) 43 or similar image conversion unit. The continuous signal is fed into embedded cryptographic operating logic 44 for conversion from video content 11 to encrypted video
30 content 14 (shown in FIGURE 1). The operating logic 44 includes four components interconnected via a bus 48: processor 45, frame buffer 46, memory

47 and removable memory 51. The memory 47 stores both operational program logic and transient data. The processor 45 executes instructions stored in the memory 47 to control the recordation, processing and transformation of the continuous signal 21 into encrypted video content 14 on a videotape 50. The
5 frame buffer 46 converts the continuous signal 21 into individual frames 23.

The removable memory 51 preferably includes a program 53 and an encryption key 54. The program 53 includes instructions for encrypting the frames 23 using the encryption key 54. In the described embodiment, the removable memory 51 operatively couples to a standardized connector 52,
10 thereby enabling multiple encryption keys 54 to be used in conjunction with the video camera 41. The processor 45 executes the program 53 to encrypt the frames 23 into encrypted frames 26 which are then stored on a preferably transportable videotape 50 via a tape recordation transport assembly 49.

In a further embodiment, the program 53 includes instructions for digitally
15 signing the frames 23 using the encryption key 54, as further described below with reference to FIGURE 12. The processor 45 executes the program 53 to generate a cryptographic hash of the frames 23. The hash is then encrypted using the encryption key 54 to generate a digital signature which is stored on the preferably transportable videotape 50.

FIGURE 5 is a block diagram showing the components 60 of a digital
20 video player 61 using embedded cryptographic security. As with FIGURE 4, for clarity of presentation, only components pertinent with reference to the decryption process 30 (shown in FIGURE 3) are described, as the remaining opto- and electro-mechanical functions would readily be known to one skilled in the art. In
25 addition, sound recordation and reproduction components have been omitted, as the processing of sound data is analogous to image data and would be handled in an identical manner.

Encrypted video content 14 is retrieved from a videotape 69 and converted
into a reconstructed signal 39 (shown in FIGURE 3). The encrypted video
30 content 14 is fed into operating logic 62 for conversion to a reconstructed continuous signal 39. The operating logic ("operating logic") 62 includes four

components: processor 63, frame buffer 64, memory 65 and removable memory 70 connected by bus 67. The memory 65 stores both operational program logic and transient data. The processor 63 executes instructions stored in the memory 65 to control the retrieval, decryption and transformation of the encrypted video content 14 from a videotape 69 into a reconstructed video signal 39. Individual encrypted frames 34 are retrieved from the videotape 69 via a read transport assembly 68 and read into the frame buffer 64. The removable memory 70 preferably includes a program 72 and a decryption key 73. The program 72 includes instructions for decrypting the encrypted frames 34 using the decryption key 73.

In the described embodiment, the removable memory 70 operatively couples to a standardized connector 71, thereby enabling multiple decryption keys 73 to be used in conjunction with the video player 61. The processor 63 executes the program 72 to decrypt the encrypted frames 34 into decrypted frames 37. The decrypted frames 37 are formed back into a reconstructed video signal 39 by the frame buffer 64 and output as a video signal on signal connector 74.

In a further embodiment, the program 72 includes instructions for verifying digitally signed frames 34 using the decryption key 73, as further described below with reference to FIGURE 12. Digitally signed video content 14 is retrieved from the videotape 69. The processor 63 executes the program 72 to decrypt a cryptographic hash of the frames 34 using the decryption key 73. A hash of the unverified frames is generated and compared to the decrypted hash. Matching hashes verify the veracity of the data and the identity of the author.

FIGURE 6 is a flow diagram showing a method 80 for automatically protecting video content using embedded cryptographic security, in accordance with the present invention. Raw video content 11 (shown in FIGURE 1) is encrypted using embedded cryptographic operating logic 44 (shown in FIGURE 4) (block 81), as further described below with reference to FIGURE 7. The encrypted video content 14 is then optionally transported (block 82) from a recording device to a playback device, such as the video camera 12 and video player 15 of FIGURE 1, respectively. Finally, the encrypted video content 14 is

decrypted using embedded cryptographic operating logic 62 (shown in FIGURE 5) (block 83), as further described below with reference to FIGURE 8. The method then completes.

FIGURE 7 is a flow diagram showing a routine 90 for encrypting video content for use in the method 80 of FIGURE 6. A raw video signal 21 (shown in FIGURE 2) is received (block 91) and individual frames 23 are generated (block 92) using a frame buffer 46 (shown in FIGURE 4). For each of the frames 23, the following steps are performed (blocks 93-96). Each frame 23 is encrypted, preferably using a public key (block 94) to generate an encrypted frame 26. Each encrypted frame 26 is then stored as recorded data on a videotape 29 (block 95). The foregoing steps (blocks 94-95) are repeated for each of the frames 23 (blocks 93-96). This routine is repeated until the raw video signal 21 ends (block 97), after which the routine returns.

FIGURE 8 is a flow diagram showing a routine 100 for decrypting encrypted video content 14 for use in the method 80 of FIGURE 6. The decryption key is first credentialed using a pass-phrase or password (block 101) prior to decrypting the encrypted frames 34 (shown in FIGURE 3). If the pass-phrase is not valid (block 102), an error condition is generated (block 103). If the cryptographic pass-phrase or password is valid (block 102), for each of the encrypted frames 34, the following steps are performed (blocks 104-110). Each encrypted frame 34 is decrypted, preferably using a private key (block 105). Each decrypted frame 37 is then stored in the output buffer for reconstruction as video (block 106). The output buffer is checked (block 107). If the video content is ready for playback (block 108), playback begins (block 109). When playback begins, the decrypted frames 34 stored in the output buffer are reconstructed into a video signal 39 (block 109). Otherwise, the process continues with the next encrypted frame 34 (block 110). The foregoing steps (blocks 105-109) are repeated for each of the encrypted frames 34 (blocks 104-110). The routine then returns.

FIGURE 9 is a process flow diagram showing the digital signing of the video content using the video camera of FIGURE 1. The video content 11 is

represented by a substantially continuous signal 121 that is generated by the video camera 12 as an electronic representation of the images and sounds being recorded. The continuous signal 121 is divided (transition 122) into discrete frames 123 of information having a fixed size. A cryptographic hash 125 is
5 generated over each selected frame (transition 124) and the cryptographic hash 125 is encrypted using an encryption key 127, as further described below with reference to FIGURE 12, to generate a digital signature 128. The frames (not shown) and digital signature 128 are then recorded (transition 129) onto a videotape 131. Note only signed video content passes the physical boundary 130
10 separating the video camera 12 (shown in FIGURE 1) and the video tape 131.

FIGURE 10 is a process flow diagram showing the verification of digitally signed video content using the video player of FIGURE 1. A videotape 141 storing the digitally signed video content 14 is read and a digital signature 143 retrieved (transition 142) by the video player 15. The digital signature 143 is
15 decrypted using a decryption key 145 and a cryptographic hash 146 is extracted (transition 144) from the decrypted digital signature 143, as further described below with reference to FIGURE 13. A digitally-signed frame 147 is extracted (transition 155) from the video tape 141. A second cryptographic hash 149 is generated (transition 148) from the extracted frame 147. The cryptographic
20 hashes are compared (transition 150) and, if matching, the frames 151 are reassembled (transition 152) into a reconstructed continuous signal 153 for viewing, processing or storage. Note only signed video content passes the physical boundary 154 separating the video tape 141 and the video player 15 (shown in FIGURE 1).

FIGURE 11 is a flow diagram showing a method 160 for automatically authenticating video content using embedded cryptographic security, in accordance with the present invention. Raw video content 11 (shown in FIGURE 1) is digitally signed using embedded cryptographic operating logic 44 (shown in FIGURE 4) (block 161), as further described below with reference to FIGURE
30 12. The digitally signed video content 14 is then optionally transported (block 162) from a recording device to a playback device, such as the video camera 12

and video player 15 of FIGURE 1. Finally, the digitally signed video content 14 is verified using embedded cryptographic operating logic 62 (shown in FIGURE 5) (block 163), as further described below with reference to FIGURE 13. The method then completes.

5 FIGURE 12 is a flow diagram showing a routine 170 for digitally signing video content for use in the method of FIGURE 11. A frame having a variable length is received as input (block 171) using a frame buffer 46 (shown in FIGURE 4). A fixed-length cryptographic hash 125 (shown in FIGURE 9) is generated using a one-way hashing function (block 172), such as described
10 "Introduction to Cryptography," <http://www.pgpi.org/doc/guide/6.5/en/intro/>, Networks Associates Technology, Inc., Santa Clara, California (2001), the disclosure of which is incorporated by reference. The cryptographic hash 125 is encrypted, preferably using a private key (block 173) and a digital signature 128 is created (block 174) using the encrypted cryptographic hash 125, after which the
15 routine returns.

 FIGURE 13 is a flow diagram showing a routine 180 for verifying digitally signed video content for use in the method of FIGURE 11. A digital signature 128 is retrieved from digitally signed video content and decrypted, preferably using a public key (block 181). A cryptographic hash is extracted from
20 the decrypted digital signature (block 182). A second cryptographic hash is generated from the signed frame from the digitally signed video content using the same one-way hashing function used to generate the extracted cryptographic hash (block 183). The cryptographic hashes are compared (block 184) and, if both match (block 185), the veracity of the data and identity of the author are verified
25 (block 186). Otherwise, an error is generated (block 187) indicating possible data compromise. The routine then returns.

 FIGURE 14 is a process flow diagram 200 showing the digital signing of encrypted video content using the video camera 12 of FIGURE 1, in accordance with a further embodiment. The video content 11 is represented by a substantially
30 continuous signal 201 that is converted into frames 203 having a fixed size (transition 202) by the video camera frame buffer 53. The frames are encrypted

(transition 204) into encrypted frames 206 using a public cryptographic key 205. A cryptographic hash 209 is generated from selected frames 203 (transition 210). A one-way cryptographically strong hashing function is applied to each frame. The cryptographic hash is digitally signed (transition 207) to create a digital
5 signature 209 using a private cryptographic key 208. The encrypted frames 212 and digital signature 213 are combined (transitions 210 and 211, respectively) and stored onto a "videotape" 215 (transition 214) as an electronic representation of the images and sounds being recorded.

In the described embodiment, each frame 203 is digitally signed on an
10 individual basis. However, groups of combined frames can be signed for improved performance. For example, five frames could be signed as a single entity. Digital signatures can also be combined with encryption to optimize video content protection. Single or groups of encrypted frames can be digitally signed.

FIGURE 15 is a process flow diagram 220 showing the authentication of
15 digital signed encrypted video content using the video player 16 of FIGURE 1, in accordance with a further embodiment. Encrypted video content 13 is read from a crypto-embedded videotape 14 by the video player 16 (shown in FIGURE 1). The encrypted video content 13 is retrieved as a sequence of encrypted frames (not shown) stored by the cryptographic operating logic in the crypto-embedded
20 videotape 14 during the digital signature process 200 of FIGURE 2. Each encrypted frame 221 is decrypted (transition 222) using a private cryptographic key 223 to create a decrypted frame 224. A cryptographic hash (*Hash'*) 226 is generated from each decrypted frame 224 (transition 225). A one-way cryptographically strong hashing function is applied to each frame. As well, a
25 digital signature 227 is authenticated (transition 228) using a public cryptographic key 229 to re-create the cryptographic hash 230 generated from the original framed video content. The two cryptographic hashes are compared and, provided the two cryptographic hashes are matching, combined into decrypted frames 233 (transitions 231 and 232). The decrypted frames 34 are reassembled (transition
30 234) into a "videotape" 37 for viewing, processing or storage as a continuous signal 235.

While the invention has been particularly shown and described as referenced to the embodiments thereof, those skilled in the art will understand that the foregoing and other changes in form and detail may be made therein without departing from the spirit and scope of the invention.

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